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Explorations in Cognition. By D. A. Norman, D. E. Rumelhart, and the LNR Research Group. Freeman, San Francisco, 1975, 114 illus., 13 tables, $13.50, xviii + 430 pp.

During the past few years, psycholinguistics has seen the publication of several monographs of a new kind—new for at least three reasons. First, they develop theories on a component of language behavior that has been seriously neglected: "knowledge of the world." Second, in one way or another, they draw upon ideas and methods of artificial intelligence. Third, the scope of the theories is unusually broad and goes beyond psycholinguistics proper: they extend this coverage to aspects of human memory, problem solving, and perception. These are the books that I have in mind: *Human Associative Memory* by J. Anderson and G. Bower (Washington, D.C.: Winston, 1973), *The Representation of Meaning in Memory* by W. Kintsch (Hillsdale, N.J.: Erlbaum, 1974), *Conceptual Information Processing* by R. Schank (Amsterdam: North-Holland, 1975), *Perception and Language* by G. Miller and P. Johnson-Laird (Cambridge, Mass.: Harvard University Press, 1976), and the volume under review.

It is the collective merit of the research described in these five volumes to have set the stage for a realistic treatment of meaning in psychological theories of understanding and speaking. Moreover, they have imported into psycholinguistics a style of theorizing which has proved very useful in other areas of cognitive psychology: the theory of some piece of behavior is set up as a *process model* which is actually able to display that behavior (or, at least, as a model which could be changed to such a process model in a straightforward or even trivial manner).

The *Explorations* described in the present volume were carried out by the LNR (or "ELINOR") research group which was formed (around 1970) by Peter Lindsay, Donald Norman, and David Rumelhart of the University of California in San Diego and has since become one of the leading projects in the subfield of artificial intelligence called natural language processing.

The heart of the book is formed by Chapters 1, 2, 3, and 7, jointly written by Norman and Rumelhart, which contain the basic philosophy, the theory, and the computer implementation of the theory. The basic philosophy is summed up by the term "schema": world knowledge is considered as "a structural framework upon which newly acquired information must be fastened. This skeletal or schematic representation then guides both interpretation of information and the search for new information to fill the gaps left in the structure" (p. 6). The theory specifies in much detail how to build schemata which actually do this job. The mechanisms Norman and Rumelhart come up with are called "active structural networks" and represent both declarative and procedural knowledge. The computer system MEMOD ("memory model") is capable of constructing and modifying such networks; it can operate on the information in the nets for the purpose of locating and retrieving information, constructing answers to questions, making inferences, etc. MEMOD is addressed and controlled through an English-like programming language of augmented transition networks (ATNs) as described by Ronald Kaplan in Chapter 5.

In Chapters 8 and 13, SOL and MEMOD are put to work in programs displaying some real language behavior. David Rumelhart and James Levin present a language comprehension system called *Verbworld* which handles a subset of English for the purpose of verifying statements and answering matter-of-fact questions. Greg Scragg's program LUIGI answers a more difficult type of question about processes. For instance, "What utensils would I get dirty if I made a cake?" (p. 368). LUIGI knows about recipes, kitchen utensils, foodstuffs, etc. To answer this question, he has to think through the entire process of making a cake and check which utensils are being dirtied at each step. These chapters complete the theory formation and model development part of the book.

The remaining seven chapters fit under the heading "Evaluation and Application." In Chapter 4, Allen Munro evaluates the LNR semantic representations in the light of current linguistic theory, especially generative semantics. Chapter 6 (by Albert Stevens and David Rumelhart) uses an ATN grammar to account for reading errors that occurred when experimental subjects were reading aloud paragraphs of connected discourse.

Chapters 9 and 10 (by Dedre Gentner and Adele Abrahamson, respectively) develop detailed semantic representations for two classes of verbs: verbs of possession and verbs of motion. Their analyses make use of "basic" or "primitive" semantic elements. The psychological reality of at least some of these elements is supported by the results of two memory experiments. In a developmental study, Gentner demonstrates that the semantic complexity of verbs of possession (compare *give* with *sell*) is paralleled by the difficulty children experience when trying to act out the meaning of sentences that contain those verbs.

The realm of language behavior is left behind in Chapters 11, 12, and 14. Stephen Palmer develops some ideas about, among other things, the representation of visually perceived information, and combats the widely held belief that analog (picturelike) representations are essentially different from propositional (sentencelike) ones. Marc Eisenstadt and Yaakov Kareev are concerned with the planning-ahead strategies people use while playing games like chess and go. Especially the "progressive deepening" strategy that is typical of human players receives much attention and is explained in terms of the limitations of working (short-term) memory. The final chapter by Marigold Linton presents the setup and some early results of a research project into the long-term memory for real-world events. Linton, who serves both as experimenter and as subject, made written records of two events a day for a total period of 5 years. In this way, she was able to circumvent the basic problem that is encountered in studies on long-term natural memory: at the time of testing, the experimenter has no detailed and reliable information about the events being remembered.

There is only one general point of criticism that I want to make. Very often, the authors fail to point out the relation of their model/theory with competing opinions in the field, for example, those expressed in the volumes listed previously. Usually, the existence of other theories is acknowledged, but similarities and differences, advantages and disadvantages of the various approaches are left undiscussed. This also applies to some of the experimental data. How can Gentner's data which support the idea of lexical decomposition in sentence memory tasks be reconciled with Kintsch's (1974) data, obtained in similar experiments, that argue against that idea? Also, do the results of her developmental study (see above) really support the semantic analysis of verbs of possession? *Give* is indeed semantically less complex than *sell*, but I doubt whether this is why children learn *give* earlier. Verbs of motion like *walk* and *run* are semantically more complex than *move*, but I wouldn't be surprised if *move* is acquired later than *walk*.

Given the importance of its subject matter, as I indicated in the beginning of this review, and because of the high to very high quality of its individual chapters, the book must be evaluated as an enrichment of the psycholinguistic literature. It is especially recommended because of its very clear style of exposition.

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